JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1997, **30,** 615–625 NUMBER 4 (WINTER 1997)

AN EVALUATION OF METHYLPHENIDATE AS A POTENTIAL ESTABLISHING OPERATION FOR SOME COMMON CLASSROOM REINFORCERS

JOHN NORTHUP, IANTHA FUSILIER, VICTORIA SWANSON, HENRY ROANE, AND JOHN BORRERO

LOUISIANA STATE UNIVERSITY

We conducted reinforcer assessments for 3 boys with a diagnosis of attention deficit hyperactivity disorder who alternately received either placebo or previously prescribed methylphenidate. Our purpose was to evaluate whether methylphenidate altered the relative reinforcing effectiveness of various stimuli that are often used in classroom-based behavioral treatment programs (e.g., activities, tangible items). Results showed clear differences for some stimuli between reinforcer assessments conducted when participants had received methylphenidate compared to placebo. Results suggest that methylphenidate might act as an establishing operation for some common classroom reinforcers. Implications for the development and evaluation of behavioral treatments are discussed.

DESCRIPTORS: reinforcer assessment, methylphenidate, attention deficit hyperactivity disorder, establishing operations

Methylphenidate (MPH; Ritalin®) is a stimulant medication that is commonly and increasingly prescribed for children with a diagnosis of attention deficit hyperactivity disorder (ADHD) and is often effective for the immediate management of a variety of disruptive or maladaptive behaviors (Barkley, 1990; Safer, Zito, & Fine, 1996). It has been suggested that the combination of MPH and behavioral treatments for disruptive behaviors in the classroom can have separate, additive, or interactive effects (e.g., Cooper et al., 1993; Pelham, Carlson, Sams, Dixon, & Hoza, 1993; Rapport, Denny, DuPaul, & Gardner, 1994; Rapport, Murphy, & Bailey, 1982; Rapport, Stoner, DuPaul, Birmingham, & Tucker, 1985). Although interactive effects between MPH and behavioral treatments have been suggested by previous studies (Northup, Jones, et al., 1997; Whalen, Henker, Collins, Finck, & Dotemoto, 1979; Wilkinson, Kircher, McMahon, & Sloane, 1995), clear demonstrations and plausible explanations for such an interaction have been rare.

It is possible that MPH might produce interactions between the medication and behavioral treatments by acting as an establishing operation for some common classroom stimuli (Poling, 1986). An establishing operation is an environmental event or stimulus condition that alters the reinforcing (or punishing) effectiveness of other events (Michael, 1993). In other words, it changes the status of a stimulus as a reinforcer or punisher and "establishes the conditions under which consequences may become effective as reinforcers or punishers" (Catania, 1992, p. 15). An establishing operation not only increases the momentary effectiveness of a particular stimulus as reinforcement, but should also increase (or decrease) the frequency of behaviors that have been previously associated with that type of reinforcement (Mi-

We thank John de Back for his invaluable assistance as consulting psychiatrist, all of the staff of the summer program, and the Louisiana State University Laboratory School. We also thank Tim Vollmer for his helpful comments on an earlier version of this manuscript. This study was funded, in part, by the Louisiana State Board of Regents, Louisiana Educational Quality Support Fund.

Correspondence should be sent to John Northup, Department of Psychology, Louisiana State University, Baton Rouge, Louisiana 70803.

chael, 1993). For example, Vollmer and Iwata (1991) demonstrated that even brief periods of deprivation and satiation altered the response rates associated with socially mediated positive reinforcers (food, attention, music). Although deprivation and satiation are the most common examples of establishing operations, they are but two of many possibilities (Catania, 1992).

Several conditions need to be satisfied to provide a convincing demonstration of the effects of MPH as a potential establishing operation. First, a particular stimulus must be demonstrated to function as a reinforcer. Second, the relative reinforcing effectiveness of the stimulus must be shown to change as a function of MPH. That is, the frequency or rate of the previously reinforced behavior must change when an individual receives MPH rather than placebo. Third, the effects must be replicable. Finally, the availability and the schedule of reinforcement must remain constant.

The purpose of this study was to evaluate whether MPH might act as an establishing operation for various stimuli that are often used in classroom-based behavioral treatment programs (e.g., activities, tangible items). We first conducted empirical reinforcer assessments for 3 boys with a diagnosis of ADHD and demonstrated the reinforcing effectiveness of various token coupons. The reinforcer assessments were subsequently repeated when the children alternately received either placebo or previously prescribed MPH. It is suggested that any differences in the results between assessments conducted after a child has received methylphenidate compared to placebo could have important implications for the development and evaluation of behavioral treatments. In addition, such evaluations could contribute to a further understanding of how methylphenidate might interact with environmental events to produce the frequently observed behavioral effects.

METHOD

Participants and Setting

Participants were 3 boys who attended a summer program for children with ADHD. The program was conducted each weekday between 8:30 a.m. and 11:30 a.m. for 3 weeks in a classroom at a university laboratory school. This study was conducted in conjunction with ongoing medication evaluations, and participation required that (a) the parents explicitly requested a medication evaluation, (b) an evaluation was determined to be of benefit to the student, and (c) the prescribing physician agreed to participate.

A diagnosis of ADHD was a prerequisite to referral to the summer program. In addition, a consulting child psychiatrist conducted an independent evaluation prior to the program and confirmed an ADHD diagnosis for each participant. Each child also met the criteria for a diagnosis of ADHD as listed in the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV*; American Psychiatric Association, 1994) based on parent interview, endorsement of at least the minimal number of *DSM-IV* criteria as a *mild to moderate* problem on a 6-point Likert-type rating scale, and a score at least two standard deviations above the mean on a domain of attention or hyperactivity on either the Child Behavior Checklist (Achenbach & Edelbrock, 1983) or the Connors Parent Rating Scale (Goyette, Connors, & Ulrich, 1978). All participants were of at least average intellectual functioning.

Tim was a 9-year-old boy who was entering second grade in regular education. Academic assessment of math and reading indicated that he was performing at least one grade level below grade placement in both subjects. Scott, a 7-year-old boy, was expected to enter second grade in a regular education classroom. Academic assessment indicated that he was performing at or above a second-grade level in both reading and

math. Mike was a 9-year-old boy who was entering fourth grade. He also was performing at or above grade placement in reading and math.

General Procedure

The reinforcer assessment procedures were based on those of Northup, George, Jones, Broussard, and Vollmer (1996) and used token coupons to represent various categories (e.g., edible items, activities) of potential reinforcers. The dependent variable was the number of easy math problems completed to earn each type of token coupon. Easy math problems were defined as those that could be completed with greater than 90% accuracy based on prior academic assessment.

An examiner recorded the number of math problems completed, number correct, the number of each type of coupon selected, and session length immediately following all sessions. Two staff members independently scored 30% of all worksheets that were selected randomly from all children and all conditions. Interscorer agreement was 99% (range, 98% to 100%), and the number of correct problems was always greater than 90% for each participant and every session.

Baseline. During baseline, the child was seated at a table with a math worksheet and across from an examiner. Each child was given the instructions, "You can do as much as you want, as little as you want, or none at all. We will stop if you don't do any for 1 min or if you say 'done.'" A session lasted 5 min or until the child either said "done" or did no math problems for 1 min. A 1-min delay before session termination was used to insure that the child was not merely distracted.

Four initial baseline sessions were conducted when the child received placebo, and four sessions were conducted when the child received MPH in sequential phases prior to any of the following assessment procedures. Additional baseline sessions were randomly interspersed between subsequent reinforcer assessments during each medication condition in a multielement design.

Reinforcer survey. A reinforcer survey was administered verbally to each child. The survey included 36 common classroom rewards organized into six categories (six per category): (a) edible items (e.g., fruit, popcorn), (b) tangible items (e.g., certificates, stickers), (c) activities (e.g., art projects, computer games), (d) teacher attention (e.g., teacher says "good job," or "I like that"), (e) peer attention (e.g., a friend gives compliments), and (f) escape (negative reinforcement). Escape was presented on the survey as, "Get out of . . ." (e.g., math, reading). In addition, an open-ended "other" item was included for each category. A complete list of all specific items is available from the authors.

Token coupons. Seven coupons (2 in. by 5 in.) of different colors were made to represent each category of potential reinforcers and a control category (e.g., yellow for edible items, red for attention, etc.). An icon that was considered to be representative of the general category was also placed on each coupon. The back-up reinforcers for each coupon were three items from each of the six categories that were randomly selected from all items rated as *liked a lot* on each child's reinforcer survey. One coupon could be exchanged for one edible item, one tangible item, or one statement of attention. Activities and escape were time based; each coupon was worth 1 min.

Control category. A control category was developed by combining one randomly selected item from each of the six categories that was rated as being liked *not at all* on the survey.

Reinforcer Assessment Procedure

The back-up reinforcers associated with each coupon were reviewed individually with

each participant, and the child was allowed to freely sample each potential reinforcer prior to the subsequent reinforcer assessments. The criterion number of completed math problems required to earn each coupon was determined individually based on an average number completed per minute during baseline and remained constant across all sessions. The required number of math problems was 5 for Tim, 4 for Scott, and 12 for Mike.

During reinforcer assessment sessions, all seven coupons (including the control) were made available simultaneously contingent on completed math problems. All coupons were placed above a math worksheet directly in front of the child. Each child was given the following instructions:

> You can earn any of these coupons you want for doing math problems. For every *X* number of problems that you do, you can stop and take any coupon you want. You can earn up to 15 coupons, but you can do as much as you want, as little as you want, or none at all. We will stop if you say "done" or if you don't do any work for 1 min.

Each session ended when the child said "done," completed no math problems for 1 min, or earned the maximum 15 coupons. A maximum of 15 coupons per session was set to limit satiation effects.

A 10-min work session immediately followed each reinforcer assessment session and included academic materials at an instructional level (i.e., an average of 70% to 90% correct) that were selected to match those on each student's escape coupon (e.g., reading or math activities). Escape coupons could be cashed in during this work session. Subsequently, any or all token coupons could be exchanged for the designated back-up reinforcers upon request at any time. Escape coupons could also be (and were) used during later regularly scheduled activities. All coupons had to be exchanged by the end of the morning activities so that all coupons were earned and exchanged on the same day.

Medication Procedure

Each of the participants had been receiving MPH prior to participation in the program. Tim received 20 mg (0.8 mg/kg) three times a day, Scott received 5 mg (0.3 mg/kg) two times a day, and Mike received 20 mg (0.8 mg/kg) two times a day.

Each participant's prescribing physician was contacted, the purpose and procedures of the study were explained, and the physician's participation was confirmed. Each physician agreed to the child's receiving or not receiving his regular morning dosage of medication in accordance with the study's design. A consulting psychiatrist then prescribed a placebo-controlled course of medication to be received during this study. All medications were prepared by a pharmacist according to standard placebo procedures. Daily doses were packaged and coded for future identification by the pharmacist. All assessment procedures were conducted within 1 to 3 hr after oral administration.

Parents were asked to initial a medication administration checklist each day. The program director confirmed with each parent that the child had received the prescribed medication each morning and provided the parent a reminder for the next day. Only the program director was aware of the child's medication status; all observers and staff remained blind to the child's medication status. Students were usually informed of the medication evaluation and were told that some days they would get a real pill and some days they would get a fake pill. At the end of each morning, each student was asked which pill he thought he had received that day. Overall correspondence between the children's responses and actual medication status appeared to be no greater than

Table 1
Total Number of Completed Math Problems Associated with Each Type of Token Coupon Across Conditions

	Tim		Scott		Mike	
	Placebo	MPH	Placebo	MPH	Placebo	MPH
Baseline	7	30	18	12	224	521
Reinforcer assessment						
Edible	165	10	44	4	1,272	732
Tangible	25	85	96	76	36	96
Activity	15	90	44	104	0	192
Escape	15	30	0	12	132	240
Teacher attention	0	0	0	0	0	180
Peer attention	0	0	0	0	0	0
Control	0	0	12	20	0	0
Total	220	245	196	216	1,440	1,440

chance; accurate correspondence was 38% for Scott, 27% for Tim, and 57% for Mike.

Design

Reinforcer assessment sessions were conducted in a concurrent-schedules design (Sidman, 1960) in which all token coupons were available simultaneously. Two sessions were typically conducted each day at approximately 8:30 a.m. and 10:00 a.m., but no less than 1 hr apart. A minimum of four sessions were conducted for each reinforcer assessment for each medication condition (i.e., placebo or MPH). Reinforcer assessments were repeated when the child received either placebo or the previously prescribed dosage of MPH in a reversal design (ABAB).

RESULTS

Table 1 shows the total cumulative number of math problems completed across all baseline sessions, the total number of problems completed for all coupons, and the total number of completed problems associated with each type of token coupon across all sessions during placebo and MPH conditions for each participant. It should be noted that all problems completed during baseline were done in the first four sessions, that is, prior to any reinforcer assessment session. No problems were completed during any of the subsequent baseline sessions that were interspersed between the reinforcer assessment sessions. The number of problems completed for the control coupon was always zero for Tim and Mike. Scott completed 20 problems for control coupons during one assessment session when he was receiving MPH and 12 problems during one session when he was receiving placebo.

Overall, clear reinforcement effects were demonstrated for at least one or more of the coupons for each participant when either placebo or MPH was administered. When the participants were receiving placebo, coupons for edible items were associated with the largest number of completed math problems for Tim and Mike, and coupons for tangible items were associated with the largest number of completed problems for Scott.

When the participants were receiving MPH, activity coupons were associated with the largest total number of completed problems for Tim and Scott. Edible items continued to be associated with the largest number of completed problems for Mike when he was receiving MPH; however, there was a substantial reduction in the total number of problems completed.

All results were further evaluated accord-

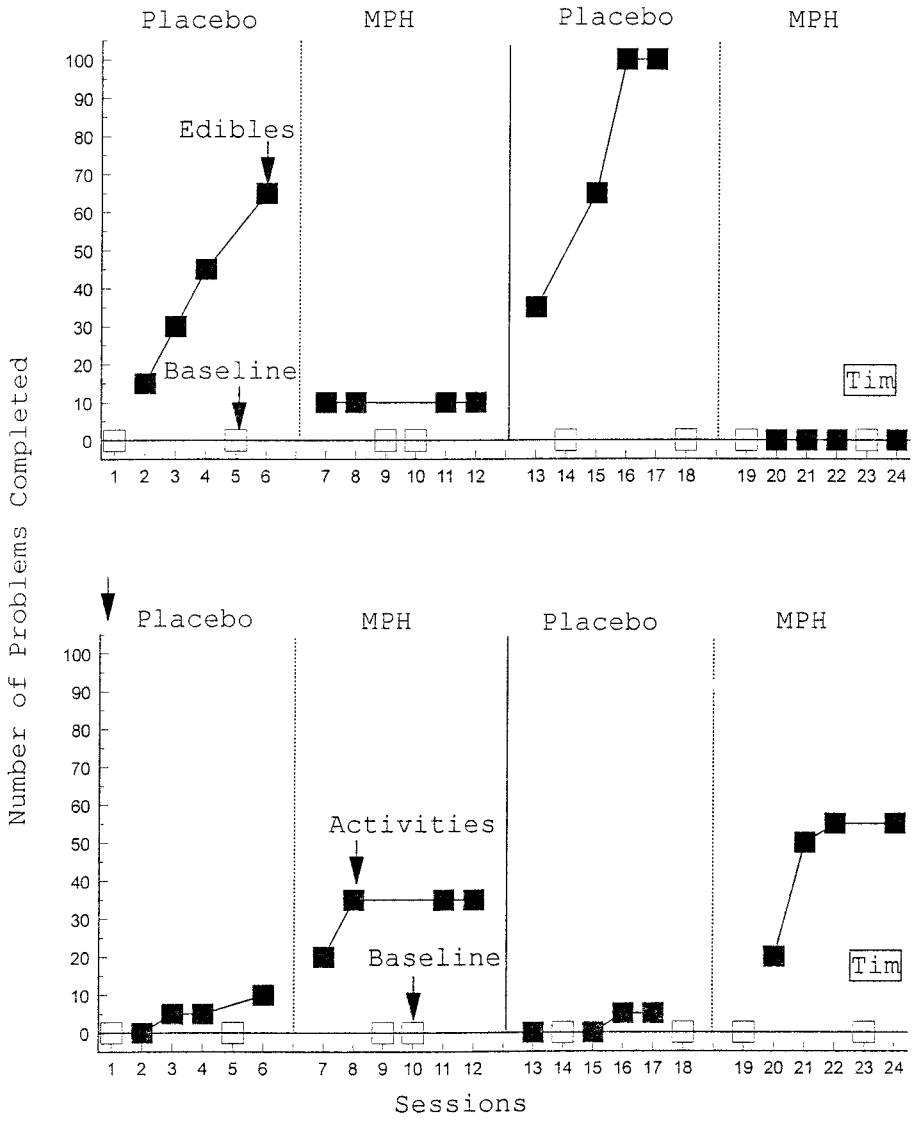

Figure 1. Cumulative number of math problems completed during baseline sessions to earn edible-item coupons (top panel) and activity coupons (bottom panel) for Tim when receiving methylphenidate (MPH) and placebo during each reinforcer assessment.

ing to the following criteria: (a) Was a token coupon associated with a clear increase in the number of completed math problems compared to baseline sessions and the control coupon? (b) Were the results replicated during the second (10:00 a.m.) reinforcer assessment? (c) If so, were there clear differences in the assessment results obtained when the child received MPH compared to placebo? The coupons for edible items met each of the above three criteria for Tim and Mike, and the activity coupons did so for Tim and Scott.

Figure 1 shows the cumulative number of problems completed during baseline sessions and to earn coupons for edible items during both reinforcer assessments for each medication condition for Tim. When placebo was administered, the results show a clear increase in the number of problems completed

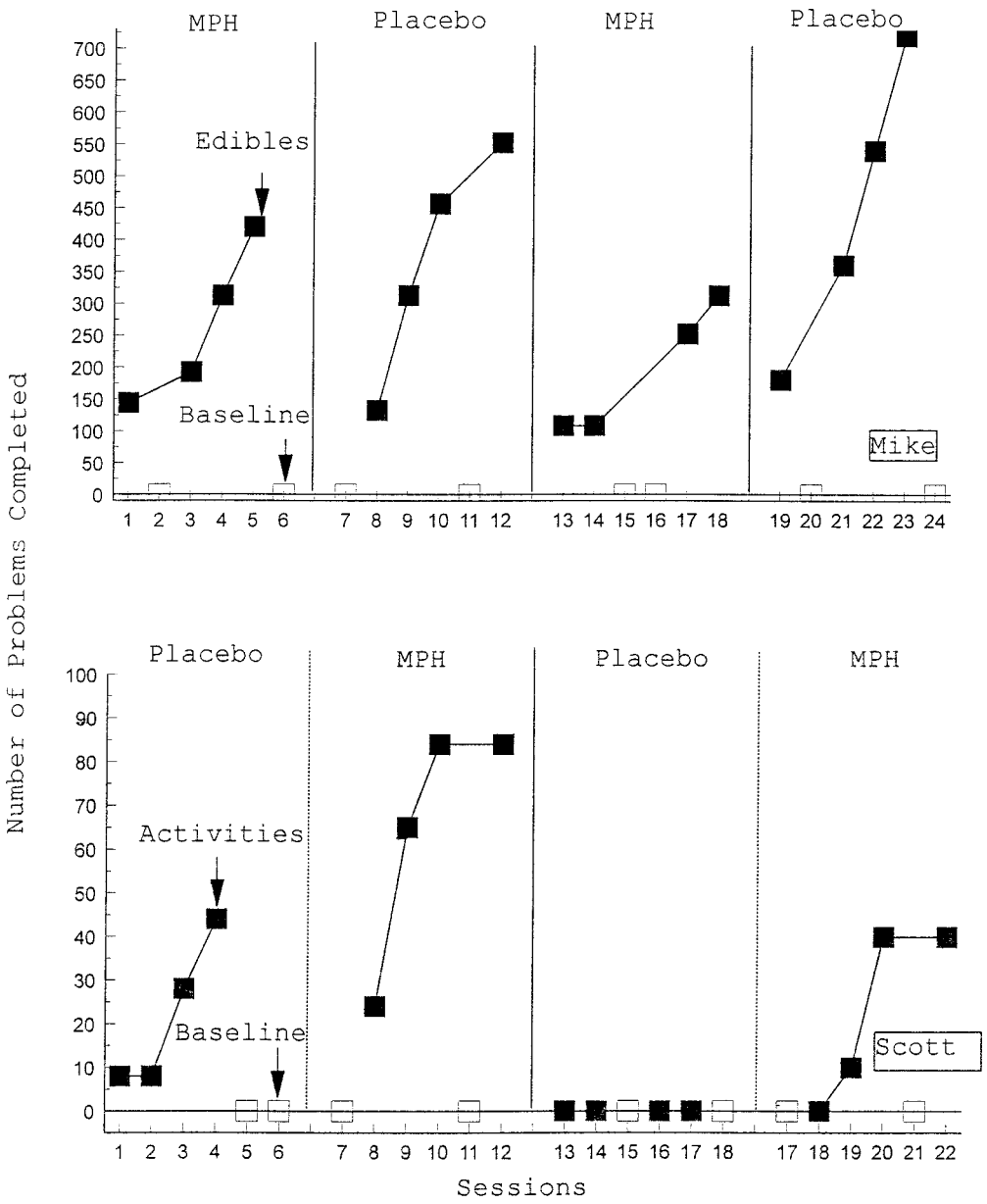

Figure 2. Cumulative number of math problems completed during baseline sessions to earn edible-item coupons for Mike (top panel) and activity coupons for Scott (bottom panel) when receiving methylphenidate (MPH) and placebo during each reinforcer assessment.

during both reinforcer assessments compared to baseline. In contrast, few or no problems were completed for edible-item coupons when Tim received MPH.

Figure 1 also shows the cumulative number of problems completed to earn activity coupons for Tim. When he was receiving placebo, activity coupons were associated with the completion of few, if any, math problems, but the number of completed problems increased during both reinforcer assessments when he received MPH.

Figure 2 shows the cumulative number of problems completed during baseline sessions

and to earn coupons for edible items for Mike. The results show a substantial increase in the number of problems completed compared to baseline when Mike received either placebo or MPH. However, there was a decrease in the number of completed problems when he received MPH compared to placebo.

Figure 2 also shows the cumulative number of problems completed to earn activity coupons for Scott. When he was receiving placebo, activity coupons were associated with the completion of some math problems during the first reinforcer assessment, but he completed no problems for activity coupons during the second assessment when he was given placebo. In contrast, there was an increase in the number of problems completed for activity coupons during both reinforcer assessments when Scott was given MPH.

DISCUSSION

The results of this study suggest that clear differences can occur in the results of reinforcer assessments obtained when children receive methylphenidate compared to placebo. The present results indicate that methylphenidate altered the relative reinforcing effectiveness of some token coupons for various stimuli that are frequently used in reinforcement-based treatment programs for children's disruptive behavior. This effect was most apparent for coupons that were exchangeable for edible items and activities. Overall, the results suggest that methylphenidate might act as an apparent establishing operation, at least for some stimuli and for some children.

As expected, the relative value of the different types of coupons was idiosyncratic across participants. Overall, the effects of MPH on relative reinforcer value also appeared to be idiosyncratic across children. When the children were given placebo, the single token coupon of greatest value was different for 2 participants (edible items for Tim and tangible items for Scott), but changed for both children when they received MPH (activities for both). In contrast, coupons for edible items remained of greatest relative value for the 3rd participant (Mike) regardless of whether he received MPH or placebo, although the number of problems completed decreased substantially when he received MPH. These individual differences are consistent with other applied studies of drug–behavior interactions associated with MPH (Poling, 1986; Wilkinson et al., 1995).

The present results suggest several potentially important implications for the development and evaluation of behavioral treatments. First, they demonstrate the possibility that stimuli known to function as reinforcers may not do so, or may not do so to the same degree, when a child receives MPH compared to placebo. Second, the alternative possibility was also demonstrated; that is, MPH may establish new or different stimuli as reinforcers. Thus, MPH has the potential to either strengthen or weaken a behavioral treatment by altering the reinforcing effectiveness of particular consequences for a particular child.

If the relative reinforcing effectiveness of various types of stimuli can vary across children as a function of MPH, then identification and control of a child's medication status may be essential for accurate identification of the most potent reinforcers for an individual child. In addition, MPH has a duration of action of only 3 to 4 hr (*Physicians Desk Reference,* 1995). As a result, MPH may be expected to be behaviorally active for only a portion of the day, even in the context of chronic dosing. Thus, any changes in reinforcing effectiveness associated with MPH would be expected to occur on a relatively brief continuum of drug absorption and distribution. This short duration of action suggests a benefit to matching

particular consequences to times when they may be most effective, as determined by the time of drug administration.

Similar concerns are relevant to evaluations of the effectiveness and relative strength of behavioral treatments (Hoza, Pelham, Sams, & Carlson, 1992; Northup, Fisher, Kurtz, Harrel, & Khang, 1997). That is, a behavioral treatment may be relatively stronger or weaker to the extent that MPH alters the reinforcing effectiveness of programmed consequences. For example, the present results suggest that the value or potency of edibles as a reinforcer for Mike was approximately 43% less when he received MPH compared to placebo.

A number of procedural issues and limitations should be noted, perhaps especially as related to any future studies. We initially conducted baseline sessions for placebo and MPH conditions prior to any reinforcer assessment sessions, and these results varied across students and drug state. Because of time constraints, we interspersed subsequent baseline sessions between reinforcer assessment sessions, consistent with a multielement design, and these baselines produced zero responding. A more extended initial baseline might be desirable for future studies, because it is possible that sequence effects (or multiple treatment interference) contributed to the later baseline results (Barlow, Hayes, & Nelson, 1984). The results for 1 participant (Scott) also showed a progressive decrease in the number of problems completed for all coupons across all sessions and medication conditions. This result was consistent with that of a general satiation effect. Because students were exposed to the same stimuli on a relatively dense schedule continuously for 3 weeks, it is possible that satiation or other reinforcer-value-altering effects also influenced the present results.

Academic tasks were provided during reinforcer assessment sessions, because they were considered to be most socially valid and are frequently subject to programmed contingencies in the classroom. A 10-min session with further academic activities followed all assessment sessions to enhance the salience of the coupon for escape and to prevent the events associated with other coupons (e.g., activities) to simultaneously allow students to temporarily escape from academic tasks. A slightly longer delay to reinforcement for other coupons was recognized but was considered to be the lesser concern in the present study. However, it is unknown whether the reinforcing effectiveness of the coupons might also vary as a function of different tasks, activities, or conditions associated with the reinforcer assessments.

Finally, although the availability and schedule of reinforcement were held constant, multiple sources of reinforcement were available simultaneously (i.e., six token coupons). The effects of any potential establishing operation might be more clearly demonstrated if stimuli were presented singly or sequentially (Smith, Iwata, Goh, & Shore, 1995).

Overall, the present results suggest that behavioral consequences may need to be more carefully described and controlled during both research and clinical evaluations of the separate and combined effectiveness of MPH and behavioral treatments. The results also suggest that a more thorough applied behavior analysis of the effects of MPH may be a fruitful and needed direction for future research.

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Received October 10, 1996
Initial editorial decision November 30, 1996
Final acceptance June 16, 1997
Action Editor, Patrick C. Friman

STUDY QUESTIONS

1. What are the characteristics of an establishing operation (EO)? Explain how taking an appetite suppressant pill might serve as (or alter) an establishing operation.

2. What was the purpose of the study and what are its implications?

3. How did the authors select the reinforcers to be evaluated?

4. Describe the procedures used during the reinforcement assessment sessions.

5. What types of experimental designs were used to evaluate the effects of reinforcement and MPH?

6. In light of the data portrayed in Table 1, how might the above example of taking an appetite suppressant apply to the results of the study?

7. Cumulative graphs, such as those shown in Figures 1 and 2, are usually used when either the total amount of responding or the slope of a response curve is of primary interest. When the data in Figures 1 and 2 are replotted using typical session-by-session values, what different outcomes are observed?

8. Given the results of this study, what strategy did the authors suggest for using reinforcers with children who are receiving MPH?

Questions prepared by SungWoo Kahng and Jana Lindberg, The University of Florida